Readme Document for Level 2 Global Ozone Monitoring Experiment-2A (GOME-2A) Formaldehyde Vertical Column Density Research Product based on Principal Component Analysis Retrieval Technique

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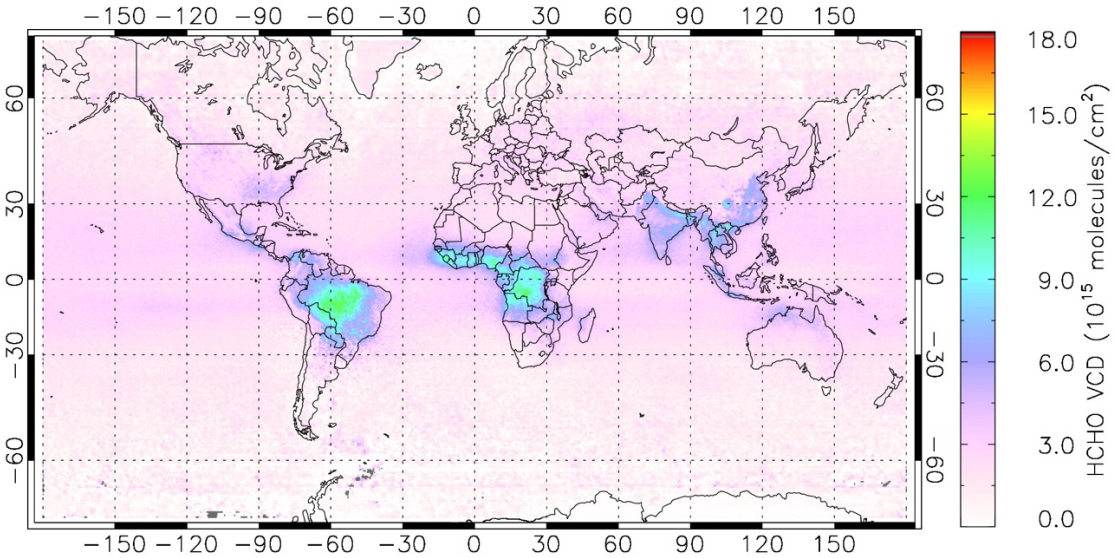

Figure 1. Annual mean GOME-2A HCHO vertical column densities (VCDs) for 2007 retrieved with the PCA-based spectral fitting algorithm, showing regions with relatively large sources of volatile organic compounds (VOCs) around the world, for example the southeastern U.S., eastern China, Southeast Asia, India, South America, and Africa.

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1. Overview

This document provides a brief introduction to the level 2 (L2) Metop-A Global Ozone Monitoring Experiment-2 (GOME-2A) formaldehyde (HCHO) vertical column density (VCD) research product. The product is produced with the NASA Goddard Space Flight Center (GSFC) principal component analysis (PCA) spectral fitting algorithm for the period of February 2007 to August 2015.

Detailed description of the PCA-based HCHO retrieval algorithm can be found in Li et al. (2015) and this document is intended as a quick reference for interested data users. Also please note that only limited validation effort has been afforded to the research product, which is offered on a best effort basis.

2. Product description

Each level 2 (L2) product file covers the sunlit portion of a GOME-2A orbit with an approximately 1920 (960) km wide swath before (after) July 15, 2013 . Each swath contains measurements from approximately 15,000 ground pixels or footprints, produced when the instrument operates in the nominal nadir scanning mode. The ground pixel size was approximately 40 km along the satellite track and 80 km across the track before July 2013, and has since been reduced to 40×40 km^2. In the nominal nadir scanning mode, measurements are made for 14 or 15 swaths per day, and global coverage is achieved in about 1.5-3 days. For more information about the GOME-2 instrument and different modes, visit the EUMETSAT website (https://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Metop/MetopDesign/GOME2/index.html).

The product files are in HDF-5 format, and are named following the pattern below:

GOME2-METOPA_L2-GOME2AHCHO_orbret_EarthRef_VCD_YYYYMMDD_oXXXXX.h5,

where YYYY, MM, DD stand for the year, month, and day of the GOME-2A radiance measurements, respectively, and XXXXX is the orbit number.

The most relevant parameters or data fields for data users in the product files are:

- **SCD_HCHO**: slant column density (SCD) of HCHO produced by spectral fitting using HCHO cross sections. SCD represents the estimated number of HCHO molecules along the effective light path between the Sun and GOME-2A at the top of the atmosphere (TOA) for each ground pixel. The unit is molecules/cm^2, and the fill value is -1×10^{30} molecules/cm^2.

- **HCHO**: vertical column density (VCD) of HCHO, representing the estimated total number of HCHO molecules within the vertical atmospheric column between the surface and TOA over a unit area within the ground pixel. It has the same unit and fill value as SCD_HCHO.

- **HCHO_Corrected**: vertical column density (VCD) of HCHO, but corrected for biases between the retrieved HCHO VCDs and monthly mean HCHO simulated with the GMI (Global Modeling Initiative) chemical transport model over the remote East Pacific (165-180°W). It has the same unit and fill value as SCD_HCHO.

- **AMF**: air mass factor (AMF) at 340 nm that is used to convert HCHO SCD to VCD for each pixel. AMF is estimated from radiative transfer calculations and depends on various factors, particularly the *a priori* profile of HCHO. AMF is unitless and has a fill value of -1×10^{30}.

- **IntensityWeightedCloudFraction**: intensity weighted cloud fraction is provided for each pixel. It is unitless, has a valid range of 0-1.0, and a fill value of -1×10^{30}.

- **ScatteringWeight**: scattering weights (or vertically resolved box-AMFs) at 340 nm at 72 vertical layers (as defined by LayerBottomPressure and a TOA pressure of 0.01 hPa) are provided for each GOME-2A pixel. Scattering weight at a given vertical layer represents the sensitivity of TOA radiances to perturbations in the HCHO optical thickness within the layer.

- **LayerBottomPressure**: pressure at the lower edge of each of the 72 vertical layers for which scattering weights are provided. The pressure at the top of the highest vertical layer or the top of the atmosphere is 0.01 hPa.

- **GMILayerWeight**: GMI model based *a priori* profile used in the retrieval of HCHO VCD for each pixel. The profile is normalized (*i.e.*, the sum of GMILayerWeight from all 72 layers is one) and the value represents the fraction of HCHO molecules each layer contributes to the entire atmospheric column.

3. Recommendations for data filtering

We recommend that data users use HCHO_Corrected, and exclude pixels with relatively large cloud fractions (IntensityWeightedCloudFraction > 0.5), or at relatively high solar zenith angles (SZA > 70°).

For best data quality, use only data with SZA < 65°, IntensityWeightedCloudFraction < 0.3, and AMF > 0.3. Retrievals for GOME-2A pixels from the ascending node of the Metop-A satellite should not be used.

Additionally, for certain days the quality of HCHO retrievals is lower (for example, due to the lack of coverage over the Pacific that is used as a reference in retrievals) and these days should be excluded from data analysis. For a list of such days, please refer to a text file named days_to_exclude.txt.

Since July 15, 2013, GOME-2A has been taking measurements with a narrow swath. This has reduced spatial sampling and led to increased noise in the monthly or annual averaged HCHO VCDs. Data collected after July 2013 should thus be treated with caution.

4. Use your own *a priori* profiles

AMF is calculated from the scattering weight, $m(z)$, and the *a priori* profile of HCHO, $n_{HCHO}(z)$:

$$AMF = \int_0^{TOA} m(z)\, n_{HCHO}(z) dz. \quad (1)$$

Note that $n_{HCHO}(z)$ is normalized against the VCD and represents the fraction of HCHO molecules contributed by layer z to the overall HCHO molecules within the entire atmospheric column from $z = 0$ to TOA.

To make use of user-supplied *a priori* profiles, it is recommended that those profiles (in mixing ratio) first be interpolated to the layers as specified by LayerBottomPressure. The interpolated mixing ratio can then be used to calculate the partial vertical column density, as well as the normalized fraction of each layer, $n_{HCHO}(z)$. Users can then make their own estimates of AMFs using Eq. (1), and convert the SCDs of HCHO to VCDs, following Eq. (2):

$$VCD = \frac{SCD}{AMF}. \quad (2)$$

5. Data access and support

The level 2 GOME-2A HCHO research product based on the PCA retrieval technique is available, free of charge, to data users at NASA Aura Validation Data Center (AVDC: https://avdc.gsfc.nasa.gov). Please note that AVDC also supports a number of other satellite data products, and bandwidth available for data downloading may be limited. Users who need to acquire large volumes of data are encouraged to first contact AVDC at Michael.M.Yan@nasa.gov or david.e.larko@nasa.gov.

Limited support for the research product is provided on a best effort basis. Please address questions or comments to the principal investigator of the product, Dr. Can Li (can.li@nasa.gov).

6. Acknowledgements

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7. References

Li, C., J. Joiner, N. A. Krotkov, and L. Dunlap (2015), A new method for global retrievals of HCHO total columns from the Suomi National Polar-orbiting Partnership Ozone Mapping and Profiler Suite, *Geophys. Res. Lett.*, 42, 2515-2522. doi:10.1002/2015GL063204.